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THE NORTH AMERICAN SPECIES OF STEREOCAULON

LINCOLN WARE RIDDLE

(WITH NINE FIGURES)

The American species of *Stereocaulon* fall naturally into two groups. One is a typically boreal group, with *S. paschale* the central species, and a general distribution throughout British North America and the northern United States, as far south as North Carolina in the Alleghany Mountains, and in the Rocky Mountains extending into Colorado, and in the case of some of the species even into the mountains of Mexico and the South American Andes. The other group is a tropical one, represented by *S. ramulosum* and its allies, and characteristic of tropical America, from which it extends rather widely into the southern hemisphere. No American herbarium contains sufficient material for a satisfactory study of these tropical species, and for that reason the present paper is confined to a consideration of the boreal species.

Anyone who has attempted to determine material of *Stereocaulon*, or has studied the material in our herbaria, must have realized the confusion which exists in regard to the distinctive characters of the species. This confusion arises in part from the great variability of the species, and their tendency, in some cases, to intergrade. But another cause of the confusion comes from the lack of literature available to the general student and containing comparative notes on the species. This lack of comparative notes makes TUCKERMAN'S *Synopsis of the North American Lichens*, which has been the guide for most of the study of the American material, a difficult treatment to use. The classic work on the genus *Stereocaulon* is to be found in the papers of TH. M. FRIES, his *De Stereocaulis et Pilophoris commentatio* being published in 1857, and his *Monographia Stereocaulorum et Pilophororum* in 1858. These must form the basis for any careful study, but unfortunately they are rather inaccessible to American students.

The present paper is an attempt to clear up some of the existing confusion and to provide an available account of the North American species of the boreal group, which shall include comparative notes, and shall cite the specimens to be found in some of our herbaria. I have been fortunate in having access, through the courtesy of Professor Farlow, to the Tuckerman Herbarium, which contains authentic material of the following species:

S. coralloides Fr., S. denudatum Flke., S. nanodes Tuck., S. paschale var. conglomeratum Fr., S. tomentosum Fr., S. Wrightii Tuck., S. cereolinum Koerb., S. Despreaultii Del., S. glaucescens Tuck., and S. tenellum Tuck.

Professor Farlow's own herbarium contains an authentic specimen of *S. foliiforme* Hue; and Professor Fink has kindly communicated a specimen of *S. alpinum* Laur. from Laurer's herbarium, which I have taken to be authentic.

In addition to the Tuckerman collection (cited as "Tuck"), the following herbaria have furnished the basis for study. The abbreviations in parentheses are those used in the body of this paper in the citation of specimens.

1. Cryptogamic Herbarium of Harvard University, including the personal collection of Professor W. G. Farlow. (H)
2. Herbarium of Wellesley College. (W)
3. The Clara E. Cummings lichen collection, Wellesley College. (CEC)
4. The C. J. Sprague collection at the Boston Society of Natural History. (BSNH)
5. Herbarium of the Thoreau Museum of Natural History, Middlesex School, Concord, Mass. (Th)
6. Herbarium of the University of Vermont, including the collections of C. C. Frost and Dr. C. G. Pringle. (UVM)
7. Herbarium of Brown University. (B)
8. Herbarium of Yale University. (Y)
9. Herbarium of the New York Botanical Gardens. (NY)
10. Herbarium of the Geological Survey of Canada. (Can)
11. The Mt. Desert Herbarium (in the possession of Mr. E. L. Rand). (Mt.D)
12. Herbarium of Professor Bruce Fink, Oxford, Ohio. (F)
13. Herbarium of L. W. Riddle, Wellesley, Mass. (R)

If my interpretation of the principles of generic nomenclature is correct, ACHARIUS should be cited as having definitely established the genus *Stereocaulon* in *Methodus Lichenum* (1803), p. 314, with *Lichen ramulosus* Swartz as the type species. It is true that the name had been used by three previous authors, but none of these can be held to have established the genus, according to present ideas. SCHREBER first published the name with a brief diagnosis in LINNAEUS' *Genera Plantarum*, ed. 8 (1791), p. 768, but no species is cited under the genus. SCHRADER, in *Spicilegium Florae Germanicae* (1794), p. 113, used the name with a single species, *S. corallinum*, a species based, however, on an imperfect lichen which later proved to be a *Pertusaria*. Finally, HOFFMAN, in *Deutschlands Flora*, II (1795), p. 128, gives a genus *Stereocaulon*, with nine species; of these nine only three are now recognized as belonging to the genus, the others included two species of *Sphaerophoron*, one *Collema*, one *Lichina*, and two imperfect forms; HOFFMAN'S genus, therefore, "embraced elements altogether incoherent" and hence cannot be considered valid. ACHARIUS thus remains the first author to place the genus on a solid foundation. The generic characters may be stated as follows:

Thallus of two parts, a primary horizontal thallus, which in most cases soon disappears, and erect, solid, cylindrical, ecorticate podetia; thallus of minute, rounded or irregularly flattened squamules, which are typically gray, sometimes creamy or white, and which also cover the podetia more or less thickly; apothecia lecideine; spores fusiform to acicular, hyaline, plurilocular. —Closely related to *Cladonia*, from which it differs in the solid podetia and the plurilocular spores, the latter character also serving to distinguish this genus from *Pilophorus*.

The term "squamules" (used by ACHARIUS, E. FRIES, SCHAERER, and others) is here adopted, in preference to the term "phyllocladia" (used by TH. FRIES and by TUCKERMAN), for the thalline outgrowths which constitute the thallus of species of the § PROSTEREOCAULON, and which occur so characteristically on the podetia of all species. The term is in current use for such thalline structures in other genera of lichens, and especially in the genus *Cladonia*, with which the squamules of *Stereocaulon* are strictly homologous, although somewhat modified.

In the descriptions of the species I have made no attempt to describe all the details of the plant, many of them unimportant, but rather to give a diagnosis of the salient and characteristic features by which the species is to be recognized.

KEY TO THE SPECIES

This key is based on typical specimens. For the determination of intergrading forms, reference should be made to the comparative notes, which follow each species.

- A. Plants chalky-powdery .... 9. *S. albicans*
- AA. Plants not chalky-powdery.
  - B. Primary thallus present.
    - C. Spores 4 μ wide, ends blunt; podetia frequently ending in soredia .... 1. *S. pileatum*
    - CC. Spores 2.7 μ wide, ends pointed; podetia never ending in soredia .... 2. *S. condensatum*
  - BB. Primary thallus absent.
    - C. True squamules absent, podetia ending in flattened, foliose tips .... 8. *S. Wrightii*
    - CC. True squamules present.
      - D. Squamules of the palmate-digitate type (see fig. 7).
        - E. Podetia glabrous or faintly tomentose, cephalodia with *Stigonema*.
          - F. Podetia loosely branched and spreading 4. *S. paschale*
          - FF. Podetia in compact cushions 4*a*. *S. paschale* v. *conglomeratum*
        - EE. Podetia more or less densely tomentose, cephalodia with *Nostoc*.
          - F. Podetia repeatedly branched 5. *S. tomentosum*
          - FF. Podetia subsimple 5*a*. *S. tomentosum* v. *simplex*
      - DD. Squamules of some other type.
        - E. Squamules coralline............ 3. *S. coralloides*
        - EE. Squamules umbilicate or coarsely granular.
          - F. Podetia glabrous, cephalodia with *Stigonema* 7. *S. denudatum*
          - FF. Podetia tomentose, cephalodia with *Nostoc* 6. *S. alpinum*

Section PROSTEREOCAULON

Primary thallus persistent and closely adnate to the substratum, podetia mostly short, under 2 cm., and simple or sparingly branched;

squamules poorly developed, mostly granular.—The species of this section show resemblance to *Pilophorus*.

Koerber's name "Cereolus" for this section must be abandoned, with the exclusion of the *Lichen cereolus* of Acharius from the genus (see discussion under *S. pileatum*).

1. Stereocaulon pileatum Ach.

S. pileatum Ach. Lich. Univ. p. 582. 1810.

S. condensatum Laurer in Fries Lich. Eu. p. 203, in part. 1831; and in Tuck. Syn. Lich. New Eng. p. 46, in part. 1848.

S. cereolus Schaerer Enum. Crit. Lich. Eu. p. 178. 1850; not Ach. Meth. p. 316. 1803.

S. cereolinum Koerber Syst. Lich. Germ. (1855) p. 14. 1855; not Ach. Syn. p. 285. 1814.

Primary thallus persistent, closely adnate to the substratum, formed of granular squamules which tend to become coralline; podetia short, mostly under 1 cm., and simple or nearly so, glabrous, with scattered coralline-granular squamules; apothecia terminal, or often absent and the podetia then ending in a mass of white soredia; spores $16.5–29 \times 3.5–5\ \mu$, average $21.4 \times 3.9\ \mu$, with blunt ends; cephalodia of the type of *S. paschale* (*q.v.*).—Growing on rocks.

SPECIMENS EXAMINED

Europe: Stenh. Lich. Suec. no. 85; Moug. and Nestl. no. 947; Koerb. Lich. sel. Germ. no. 271.

Canada: Newfoundland, *Waghorne* 1893, as *S. nanodes* (Hb. Eckfeldt); Anticosti Is., *Macoun* Aug. 24, 1883 (Can); Cape Breton Is., *Macoun* July 22, 1898 (Can); Nova Scotia, *Macoun* 1883 (Tuck); *McKay* (BSNH); Grand Manan Is., *Willey* (BSNH).

Maine: Mt. Desert, *J. W. Eckfeldt* 1888 (Mt. D); Rockland, *G. K. Merrill* (NY).

New Hampshire: White Mts., Tuckerman Lich. Exs. no. 113 in part; also *Tuckerman* in Herb.; Bald Mt., *W. G. Farlow* Sept. 1905 (H); Chocorua, *W. G. Farlow* Sept. 1907 (H); Fitzwilliam, *R. H. Howe, Jr.*, Aug. 6, 1909 (R).

Vermont: Mt. Mansfield, *C. G. Pringle* no. 197 (BSNH); Willoughby, *G. G. Kennedy* July 28, 1898 (H).

Massachusetts: Chelmsford and Salem, *J. L. Russell* 1850 (Tuck); Concord, *R. H. Howe, Jr.* (Th); Ipswich, *Oakes* and *Tuckerman* Nov. 1842 (Tuck); New Bedford, *Willey* 1881 (Tuck).

New York: Adirondack Mts., *L. W. Riddle* Aug. 1908 (R).

This is the only species treated in this paper of which the synonymy is confused, the uncertainty arising on account of the doubt as to what ACHARIUS meant by his *Lichen cereolus*, described in *Lichenographia Suecicae Prodromus* (1798), p. 89, and figured as *Stereocaulon cereolus* in *Methodus Lichenum* (1803), *pl. 7, fig. 1*. In TH. FRIES'S *Monograph* (1858), p. 40, the treatment is confused, *S. cereolus* being placed as a variety under *S. cereolinum* (Ach.) Koerb., of which *S. pileatum* is made a synonym, apparently disregarding priority. But in his *Lichenographia Scandinavica* (1871), p. 55, TH. FRIES states that according to the original specimens in ACHARIUS' Herbarium, *Lichen cereolus* is synonymous with *Pilophorus Fibula* Th. Fr. This would leave *S. pileatum* the oldest name and the one to be adopted, as has indeed been done by TH. FRIES (*op. cit.*) and most recent authors.

Stereocaulon pileatum is closely allied to *S. condensatum*, with which, as indicated in the synonymy, it was at one time united by certain authors, yet the differences between the two are greater than those between *S. paschale* and *S. tomentosum*, which have been recognized as distinct since the work of ELIAS FRIES. The points of difference are as follows.

S. pileatum	*S. condensatum*
1. Squamules typically coralline.	1. Squamules granular.
2. Podetia simple and reduced.	2. Podetia stouter, often branched above.
3. Apothecia often replaced by soredia.	3. Apothecia never replaced by soredia.
4. Spores with blunt ends, and averaging 4 μ in width.	4. Spores with pointed ends, and averaging 2.7 μ in width.
5. Growing on rocks.	5. Growing on soil.

S. pileatum also shows a strong resemblance to forms of *Pilophorus*. When fertile the spore differences will of course serve for their distinction.

2. STEREOCAULON CONDENSATUM Hoffm.

S. condensatum Hoffm. Deutsch. Fl. **2**:130. 1795.

Primary thallus persistent, formed of coarse, rounded granules, intermixed with conspicuous black masses of *Stigonema*, with which are formed dark, rugose cephalodia; podetia stout, simple or fastigiately branched above; squamules granular, rarely coralline; apothecia well developed; spores 20–28×2.5–3 μ, average 23×2.6 μ, with pointed ends.—Growing on soil.

SPECIMENS EXAMINED

EUROPE: Fries Lich. Suec. no. 88; Schaer. Lich. Helv. no. 509; Anzi Lich. Ital. Suppl. no. 29; Nyl. and Norrl. Herb. Lich. Fenn. no. 87.

CANADA: Labrador, *A. P. Low* July 21, 1896 (Can); Quebec, *Macoun* Aug. 11, 1905 (Can).

Massachusetts: Wellesley, *Clara E. Cummings* in Dec. N. A. L. 26; South Sudbury, *C. M. Carr* (R); Ipswich, *Wm. Oakes* (Tuck); Duxbury, *J. L. Russell* (Tuck); New Bedford, *H. Willey* (BSNH); Mattapoisett, H. *Willey* (R).

Connecticut: Montville, *W. A. Setchell* (Tuck); Norwich, *W. A. Setchell* (H).

The differences which distinguish this species from *S. pileatum* are sufficiently indicated in the notes under the latter, to which reference may be made.

Section EUSTEREOCAULON

Primary thallus soon disappearing; podetia mostly tall, well developed, and irregularly branched; squamules well developed, cartilaginous, gray or white, but never chalky.—Spores 15–35 × 2.5–5 μ, with some minor variations among the species, but on the whole so uniform as to be without value in specific diagnosis.

3. STEREOCAULON CORALLOIDES Fries.

S. coralloides Fries Lich. Suec. no. 118. 1817; and Sched. Crit. p. 24. 1824.

S. corallinum Laurer in Fries Lich. Eu. p. 201. 1831.

S. corallinum Fries in Tuck. Syn. Lich. N.E. p. 45. 1848.

S. Despreaultii Delise ms. in Nyl. Syn. p. 249. 1858 (according to authentic specimen in Herb. Tuck.).

Podetia solitary or caespitose, erect, branched, usually extensively, glabrous or subtomentose; squamules coralline and branching, giving the plant a fibrillose appearance; apothecium medium to large (1–4 mm.), mostly terminal; cephalodia of the type of *S. paschale* (*q.v.*), usually abundant and conspicuous.—Growing on rocks (fig. 5).

SPECIMENS EXAMINED

Europe: Fries Lich. Suec. no. 118; Stenh. Lich. Suec. no. 82; Sweden, *Th. Fries*, Leighton Collection (NY), also *Nylander* (*loc. cit.*); Schaer. Lich. Helv. no. 261; Hepp Lich. Eu. no. 114; Pyrenees, *R. Spruce* in Leighton Collection (NY).

British America: Labrador, *Townsend* July 1906 (H); Newfoundland, *Waghorne* no. 46, no. 66 as *S. tomentosum*, no. 67 as *S. paschale* (CEC); New Brunswick, *Farlow* July 1892 (H); *Willey* (Tuck); Cape Breton Is., *Macoun* July 22, 1898 (Can); Nova Scotia, *A. H. Mackay* (BSNH); Ontario, *Macoun* (Can); Lake Superior, *Macoun* (Can); Vancouver Is., *Macoun* (Can); *Calder* (BSNH); *Lyall* (Tuck).

Alaska: Unalaska, *J. M. Macoun* June 4, 1897 (Can); St. Paul Is., *J. M. Macoun* June 19, 1897 (Can).

MAINE: Eastport, *Farlow* (H); West Pembroke, *Maude C. Wiegand* Aug. 11, 1909 (W); Mt. Katahdin, *J. F. Collins* in Herb.; Mt. Desert Is., *M. L. Wilson* (Mt. D).

NEW HAMPSHIRE: White Mts., Tuckerman Lich. Exs. no. 94; *E. Faxon*, as *S. denudatum* (CEC); *Clara E. Cummings* (R); *Farlow* (H).

VERMONT: Brattleboro, *C. C. Frost* (UVM).

NORTH CAROLINA: *Buckley* (NY); *J. W. Harshberger* (NY).

A beautiful species, entirely distinct from all others of the boreal group in the coralline or fibrillose squamules (fig. 8), clearly separating it from *S. paschale* and *S. tomentosum*, which it resembles in habit. Although much the rarest of the three species, it is nevertheless rather remarkable that no specimens have been seen from the central or western parts of the United States.

4. STEREOCAULON PASCHALE (L.) Ach.

Lichen paschalis Linnaeus Sp. Pl. **2**:1153. 1753 (cf. WAINIO *Revisio lichenum in herbario Linneai asservatorum* in Medd. Soc. F. et Fl. Fenn. **14**:1. 1886).

Stereocaulon paschale Acharius Meth. Lich. p. 315. 1803, in part (cf. TH. FRIES Monog. Ster. p. 58).

Stereocaulon paschale Fries emend. in Lich. Eu. p. 202. 1831.

Podetia 3 to 9 cm. high (average 6 cm.), caespitose, lax, spreading, procumbent, or rarely erect, more or less intricately branched throughout, glabrous or somewhat tomentose; squamules palmate-digitate, or margin crenate, or, on upper part of podetia, granulate, never coralline; apothecia 0.5 to 4 mm. in diameter, average 1 mm., terminal or terminal and lateral; cephalodia typically conspicuous, gray, spherical, rugose-plicate, containing *Stigonema*, sometimes fibrillose and black.—Growing on rocks, rarely on the earth.

SPECIMENS EXAMINED

EUROPE: Stenh. Lich. Suec. no. 80; Sweden, *Th. Fries* 1854, and *Tuckerman* 1842 (Tuck).

BRITISH AMERICA: Labrador, *A. P. Low* July 1896 (Can); *Waghorne*, Aug. 1891 (NY); Quebec, Gaspe County, *J. F. Collins* July 19, 1906 (R); New Brunswick, *G. U. Hay* July 1884 (Can); Nova Scotia, *Mackay* (BSNH); Ontario, many localities, *Macoun* (Can); Lake Superior, *Macoun* Canad. Lich. no. 45; Alberta, *H. L. Bolley* Aug. 1901 (F); British Columbia, *Macoun* (Can).

ALASKA: *J. M. Macoun* 1892 (Can); Sheep Creek near Juneau, *Grace E. Cooley* Aug. 5, 1891, as *S. tomentosum* (CEC); Muir Glacier, *Trelease* June 9, 1899, Harriman Exped. no. 1299, as *S. tomentosum* (CEC); Port Cla en , Behring Strait, *Trelease* July 12, 1899, Harriman Exped. no. 1266, as *S. tomentosum* (CEC).

MAINE: Eastport, *W. G. Farlow* 1877 (Tuck); Portage, *L. W. Riddle* Aug. 1907 (R); Rangeley *L. W. Riddle* Aug. 1904 (R); Orono, *L. W. Riddle* July 1907 (R); Mt. Desert, *M. L. Wilson* (Mt. D), *Sam Surrey* (R); Rockport, *G. K. Merrill* Lich. Exs. no. 40; Cumberland, *J. Blake* (NY).

NEW HAMPSHIRE: White Mts., Tuckerman Lich. Exs. no. 122; North Woodstock, *Clara E. Cummings* in N. A. L. no. 25, L. B. A. no. 151; Crawfords, *Miss Minns* (W); Warren, *Charles W. Riddle* Aug. 1908 (R); Mt. Chocorua, *H. H. Bartlett* Sept. 1906 (R); Mt. Monadnock, *W. G. Farlow* (H); *R. H. Howe, Jr.* (Th); Fitzwilliam, *R. H. Howe, Jr.*, Lich. Nov. Ang. no. 22.

VERMONT: Mt. Mansfield, *C. G. Pringle* 1879 (UVM); Willoughby, *W. G. Farlow* (H); Bristol, *L. W. Riddle* Aug. 12, 1908 (R).

MASSACHUSETTS: Pepperell, *L. W. Riddle* May 30, 1909 (R); Mt. Watatic and Concord, *R. H. Howe, Jr.* (Th); Arlington, *B. Fink* May 1895 (R); "near Boston," *T. P. Adams* (BSNH).

CONNECTICUT: Woodbridge, *G. E. Nichols* March 13, 1909 (R).

NEW YORK: Adirondack Mts., *Mrs. C. W. Harris* 1900 (R); *L. W. Riddle* Aug. 1908 (R).

OHIO: *Lesquereux?* (NY).

MICHIGAN: *E. T. Harper* Aug. 1899 (R).

WISCONSIN: *C. F. Baker* (CEC).

MINNESOTA: *Macmillan* 1894 (R); *B. Fink* July 30, 1902 (R).

OREGON: *E. Hall* 1871 (Tuck).

TUCKERMAN, following TH. FRIES, cites E. FRIES as the author of this species. The combination was first made, however, by ACHARIUS (*op. cit.*), who refers to the figure in *English botany, pl. 282*. According to the Vienna Code (Articles 40 and 41), ACHARIUS should be cited therefore as the author, even though his conception of the species was later emended by FRIES through the segregation of *S. tomentosum* and *S. coralloides*.

S. paschale is the commonest and most widely distributed species of the genus, at least in the eastern portion of North America. In the west it seems to be comparatively rare, its place being taken by *S. tomentosum*.

The two species named may be best separated from their allies by the palmate-digitate type of squamules (fig. 7). The chief difficulty, however, comes in finding satisfactory characters to distinguish *S. paschale* from *S. tomentosum*. Typical *S. paschale* is said to have glabrous podetia, while in *S. tomentosum* they are said to be densely tomentose. But a study of a sufficient amount of material shows that there are all gradations from wholly glabrous podetia through a medium amount of tomentum to densely tomentose. As the tomentum is the chief character hitherto used as diagnostic, it is clear that with such variability much confusion must result. A second character which has been used is the position of the apothecia, in typical *S. paschale* the apothecia being at least in part terminal, while in *S. tomentosum* they are said to be always lateral. Here again we have a variable character which cannot be used as a precise criterion.

In searching for a character which would by its nature be mutually exclusive for the two species, the attempt was made to use the cephalodia. The differences between the cephalodia typical of these two species are sufficiently indicated in the descriptions, to which reference may be made. To establish the taxonomic value of this structure, it was necessary to prove three points: first, both types of cephalodia must not occur on the same plant; secondly, the cephalodia must be constant enough in occurrence to be of use; and thirdly, the characteristics of the cephalodia must be correlated with the other diagnostic characters.

As has been shown by various investigators, the cephalodia of lichens are peculiar gall-like outgrowths formed by the hyphae of the thallus surrounding some foreign alga. A priori we should hardly expect that such a structure would be constant enough to be used in classification. The method adopted to prove the points mentioned was to make a statistical study of a large number of specimens of the *paschale-tomentosum* group, noting the type of cephalodium, the amount of tomentum, and the position of the apothecia, and then to tabulate the results. In this statistical study material was examined from various parts of North America and Europe, and the specimens were taken as they came in the herbaria, in order to avoid influencing the results by conscious choice. The only exception was made in the case of a few specimens which were so clearly depauperate that they could in no way be looked upon as aiding in the object sought. The results are given in the following tables:

Number of specimens examined	103
Specimens with both types of cephalodia	1
Specimens lacking cephalodia	9
Specimens lacking apothecia	22

The fact that on only one specimen studied were both types of cephalodia found shows that for practical purposes the two types are mutually exclusive. Cephalodia being present in a larger proportion of specimens than were apothecia, it follows that if apothecial characters or spore characters are of value cephalodia can equally well be used, as far as constancy of occurrence is concerned. To show correlation of characters, the results may be arranged as follows:

CEPHALODIA	APOTHECIA		
	Terminal	Mixed	Lateral
Tomentosum type....	1	13	28
Paschale type.......	11	18	3

CEPHALODIA	TOMENTUM		
	Absent	Medium	Abundant
Tomentosum type....	0	16	34
Paschale type.......	24	19	0

These tables show conclusively the extent to which *S. paschale* and *S. tomentosum* intergrade. They show also the confusion introduced by taking the presence of tomentum alone as a criterion, for, as is shown in the second table, out of 93 specimens 35 were intermediate in the amount of tomentum. With such intergrading, complete correlation of characters is not to be expected. But the tables show that the types of cephalodia are correlated to a marked degree with the two characters that have been recognized as of chief importance in separating these two species. The results of the statistical study, therefore, support very strongly the suggestion that the cephalodia, when present, are of great taxonomic value. Yet taking all available characters into consideration, there are still specimens which cannot be placed absolutely under either of these species, but exhibit characters of both. And this must necessarily be so on account of the fact that in nature *S. paschale* and *S. tomentosum* evidently form a continuous, variable series, the forms that we recognize as "typical" being merely the two extremes of this series.

Of the numerous forms of *S. paschale* which have been distinguished by European authors only one seems to be of sufficient importance in North America to receive separate treatment. This is

4*a*. STEREOCAULON PASCHALE var. CONGLOMERATUM Fries.

Fries Sched. Crit. ad Lich. Suec. **3**:20. 1824.

Podetia much branched, forming compact cushions which are closely adnate to the substratum, squamules more granular and crowded than in the type; usually sterile.—Growing on rocks.

SPECIMENS EXAMINED

EUROPE: Fries Lich. Suec. no. 89; Hepp Lich. Eu. no. 304; Sweden, *Areschoug* (Tuck).

NEW HAMPSHIRE: Mt. Monadnock, *W. G. Farlow* July 1, 1896 (H); Alton Bay, *C. J. Sprague* (BSNH).

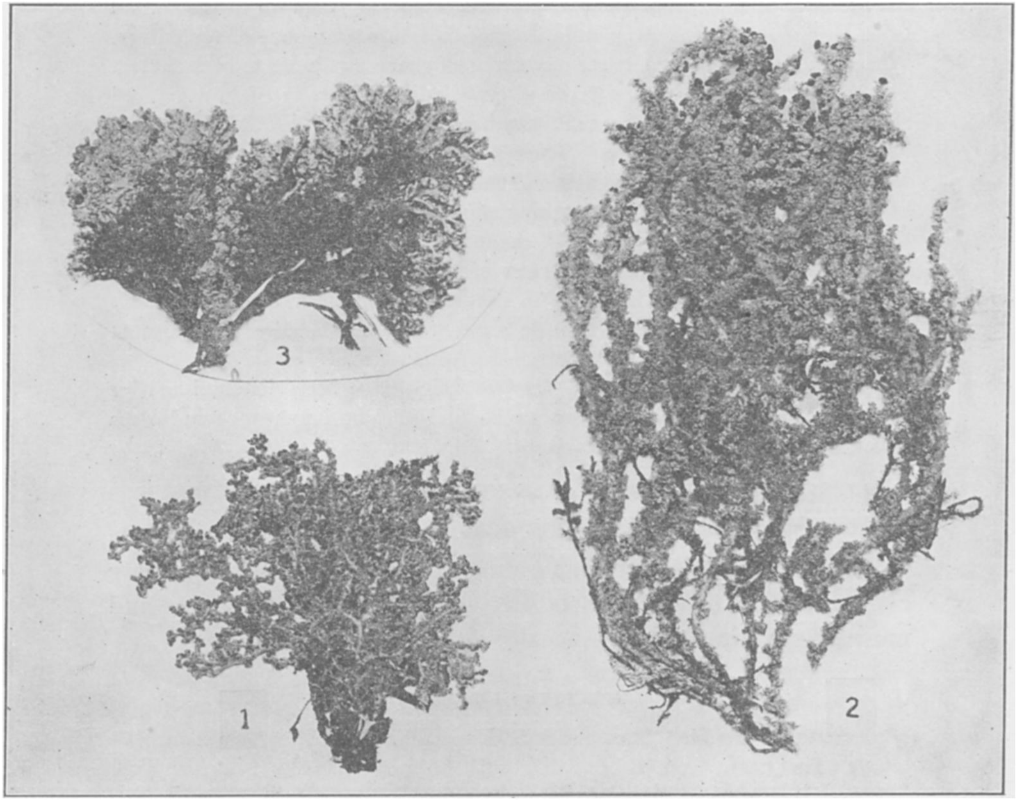
VERMONT: Mt. Ascutney, *R. H. Howe, Jr.*, Aug. 25, 1909 (Th).

MASSACHUSETTS: Annisquam, *Clara E. Cummings* 1892 (CEC); Wellesley, *Clara E. Cummings* Dec. 1884 (CEC); *L. W. Riddle* Jan. 1908 (R).

This is a reduced form of *S. paschale*, occurring either at low altitudes or on rocks with extreme exposure. It passes into the laxer, more typical form by insensible gradations. The only other species with which this variety may be confused is *S. denudatum*, and the specimens from Ipswich, Mass. (*Wm. Oakes*), and from Nantasket, Mass. (*H. Willey*), in the Tuckerman Herbarium, labeled *denudatum*, seem to be much nearer this variety of *S. paschale*. The two have a general resemblance in habit, but *S. paschale* var. *conglomeratum* is less denuded and always has indications of the palmate-digitate type of squamules typical of *S. paschale*.

5. STEREOCAULON TOMENTOSUM Fries.

S. tomentosum Fries Sched. Crit. ad Lich. Suec. **3**: 20. 1824.



FIGS. 1, 2, 3.—Fig. 1, *Stereocaulon tomentosum* Fr., typical form; specimen from Disenchantment Bay, Alaska, collected by W. Trelease, June 19, 1899, Harriman Exped. no. 1297, in herbarium of Clara E. Cummings; photo. nat. size; fig. 2, *Stereocaulon tomentosum* Fr., large form; specimen from Cascade Mts., Oregon, collected by C. G. Pringle, Sept. 20, 1881, in herbarium of Wellesley College; photo. nat. size; fig. 3, *Stereocaulon Wrightii* Tuck.; specimen from St. Michael, Alaska, collected by W. A. Setchell, University of California Expedition, 1899, in herbarium of Clara E. Cummings; photo. nat. size.

Podetia loosely attached to the substratum, erect, or spreading, 3 to 9 cm. high, average 5 cm., more or less densely tomentose; squamules palmate-digitate, abundant, more or less crowded; apothecia typically minute, 0.5 to 1 mm. in diameter, rarely larger, reaching 2 mm., lateral; cephalodia minute, verdigris-green, containing *Nostoc*.—Growing on the ground or among mosses, rarely on rocks (fig. 1).

SPECIMENS EXAMINED

EUROPE: Fries Lich. Suec. no. 90; Stenh. Lich. Suec. no. 79; Hepp Lich. Eu. no. 302; Rabenh. Lich. Eu. no. 133; Lojka Lich. Hungarici no. dh; Upsala, *Th. Fries* 1854 (Tuck); Sweden, *Nylander* in Leighton Coll. (NY).

BRITISH AMERICA: Labrador, *Waghorne* no. 33, as *S. denudatum* (CEC); Anticosti, *Macoun* Aug. 22, 1883 (Can); New Brunswick, *G. U. Hay* June 24, 1882 (Can); Gaspe County, Quebec, *Macoun* July 28, 1882 (Can); *J. F. Collins* Aug. 17, 1906 (R); Cape Breton Is., *Macoun* July 9, 1898 (Can); Nova Scotia, *Macoun* June 12, 1883 (Can); Great Bear Lake, *Richardson* (H); Lake Superior, *Macoun* July 29, 1869 (Can); *Agassiz* 1848 (Tuck); British Columbia, many localities, *Macoun* (Can); *G. Dawson* Oct. 5, 1888 (Can); Alberta, *Macoun* June 13, 1907 (Can); *L. R. Waldron* June 16, 1901 (F).

ALASKA: *Dr. Kellogg* (Tuck); *P. M. Newhall* on Univ. Calif. Exped. 1899 (CEC); *Trelease* in Harriman Exped. nos. 1267, 1297, 1300, 1301; *Coville* and *Kearney* in Harriman Exped. nos. 609, 981, 2121 (CEC).

MAINE: Eastport, *Farlow* (H); Mt. Desert, *M. L. Fernald* Sept. 18, 1892 (CEC); Cumberland, *J. Blake* Dec. 1855 (CEC).

NEW HAMPSHIRE: White Mts., Tuckerman Lich. Exs. no. 23; Crawfords, *Miss Minns* (W); North Woodstock, *Clara E. Cummings* Aug. 19, 1892 (CEC); Shelburne, *Farlow* Aug. 1894 (H); Fitzwilliam, *R. H. Howe, Jr.* (Th.)

VERMONT: Hinesburgh, *C. G. Pringle* 1878 (UVM); Brattleboro, *C. C. Frost* (UVM).

MASSACHUSETTS: Magnolia, *C. J. Sprague*, as *S. paschale* (BSNH); Duxbury, *J. L. Russell* (B); New Bedford, *H. Willey* (B).

CONNECTICUT: Ellsworth, *H. A. Green* Aug. 7, 1887 (NY).

NEW YORK: *C. F. Austin* (NY); *E. A. Burt* (F); *K. M. Wiegand* (W); *L. W. Riddle* (R).

ILLINOIS: *J. Wolf* 1888 (NY).

MINNESOTA: Various localities, *B. Fink*, in Herb.; *Macmillan* (F).

COLORADO: *T. S. Brandegee* (R); *F. E. Clements*, as *S. paschale* (H).

MONTANA: *T. A. Williams* in Dec. N. A. L. no. 292.

WYOMING: *Aven Nelson* no. 2690 (NY).

WASHINGTON: *W. W. Calkins* no. 340, as *S. paschale* (W); Puget Sound *B. Fink* June 30, 1906 (F); Longmire's Springs, *E. T. Harper* Aug. 1906 (F).

OREGON: *C. G. Pringle* Sept. 20, 1881 (W); *E. Hall* 1871 (H); *J. W. Eckfeldt* 1882 (Can).

The relationship of *S. tomentosum* to *S. paschale* is sufficiently discussed under the latter species, to which reference may be made. The palmate-digitate type of squamules will serve to distinguish these species from others having the same habit, including *S. alpinum*, our only other species with typically tomentose podetia.

Certain material has been examined from our northwest coast, especially from the Cascade Mts., Oregon, which seemed at first to be distinct from *S. tomentosum* (fig. 2). These specimens are unusually large and finely developed, with large apothecia, and bearing conspicuous white structures which at first appeared to be a new type of cephalodium. Examination of these structures failed to show any type of alga other than the *Cystococcus*, which forms the normal gonidia for the genus, and the structures cannot therefore be considered cephalodia. After careful study I am unable to look upon this Oregon material as anything more than exceptionally luxuriant *S. tomentosum*.

It is otherwise, however, with another form of *S. tomentosum*, which is undoubtedly of varietal rank and may be designated

5*a*. STEREOCAULON TOMENTOSUM var. **simplex**, var. nov.

Podetia 6–9 cm. alta, erecta, simplicia vel subsimplicia; squamulae paucae et dispersae; tomentum et apothecia et cephalodia ut in forma typica.—Habitat in locis arenosis.

Podetia 6–9 cm., tall, erect, simple or nearly so; squamules few and scattered; tomentum, apothecia, and cephalodia as in the type.—Growing in bare sandy soil (fig. 4).

Type specimens: "On sandy river bottom, Mt. Rainier region, Washington," collected by *T. C. Frye*, Aug. 14, 1904, in Herb. L. W. Riddle.

Co-type specimens: in Herb. Fink and Herb. Wellesley College.

SPECIMENS EXAMINED

OREGON: Cascade Mts., *Moses Craig* Aug. 1898 (CEC), *A. S. Foster* June 20, 1907 (R).

WASHINGTON: Mt. Rainier region *T. C. Frye* Aug. 15, 1904 (R); Olympic Mts., *T. C. Frye* Aug. 7, 1907 (R).

BRITISH COLUMBIA: Salt Spring Is. Gulf of Georgia, *Macoun* May 9, 1887 (Can).

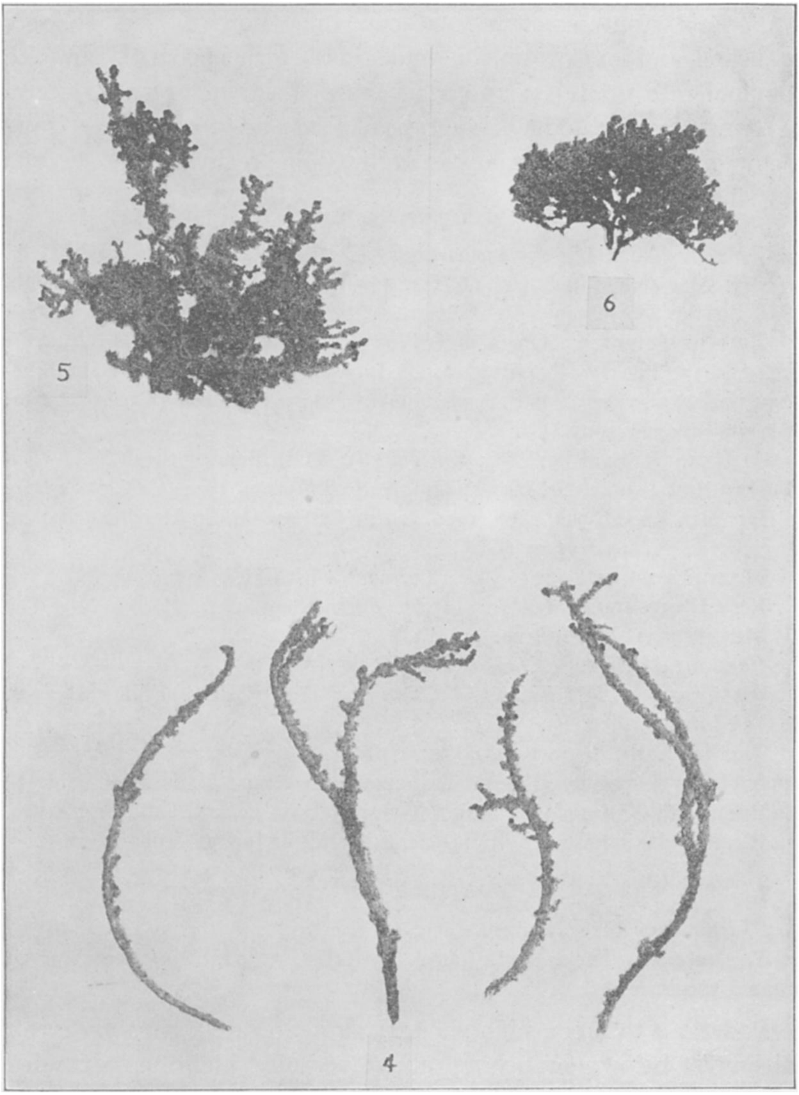
ALASKA: Davidson Glacier, *Grace E. Cooley* Aug. 15, 1891 (CEC).

This variety is very striking and distinct, and can scarcely be confused with any other North American form.

6. STEREOCAULON ALPINUM Laurer.

S. alpinum Laurer in Fries Lich. Eu. p. 204. 1831.

S. tomentosum var. *alpinum* (Laur.) Th. Fr. Comm. Ster. p. 30. 1857, and American authors.



FIGS. 4, 5, 6.—Fig. 4, *Stereocaulon tomentosum* var. *simplex* Riddle; type specimens from Mt. Rainier region, Washington, collected by T. C. FRYE, Aug. 14, 1904, in herbarium of L. W. RIDDLE; photo. nat. size; fig. 5, *Stereocaulon coralloides* Fr.; specimen from the Austrian Tyrol, collected by KERNSTOCK and issued in *Kryptogammae Exsiccati* (Vienna), no. 355, herbarium of L. W. RIDDLE; photo. nat. size; fig. 6, *Stereocaulon denudatum* Floerke; specimen with the granulate type of squamules, from Minnesota, collected by BRUCE FINK, June 19, 1897, in herbarium of L. W. RIDDLE; photo. nat. size.

Podetia stout, erect, 1 to 6 cm. tall, more or less densely branched, and tomentose; squamules in the form of coarse, crowded, conglomerate granules; apothecia (rare) medium to large, lateral or terminal; cephalodia of the type of *S. tomentosum* (*q.v.*).—Growing on exposed soil, especially in arctic-alpine regions.

SPECIMENS EXAMINED

EUROPE: Authentic specimens ex Herb. Laurer (F); Schaer. Lich. Helv. no. 263; Massalongo Lich. Ital. no. 11; Anzi Lich. Ital. Suppl. no. 26; Rabenh. Lich. Eu. no. 859; Arnold Lich. Exs. 5 no. 641*a;* Finmark, *Th. Fries* (Tuck).

BRITISH AMERICA: Greenland, *Fink* (NY); Cumberland Is., *Howgate Exped.* 1877 (Tuck); Diggs Is. Husdon Bay, *R. Bell* (Can); Labrador, *Waghorne* no. 20, also no. 21 as *S. condensatum* (CEC); *A. P. Low* (Can); Alberta, *Macoun* June 28, 1905 (Can).

ALASKA: St. Paul Is., *T. C. Kincaid* (F); Is. in Behring Strait, *C. Wright* (Tuck); Port Foulke, *Dr. Hayes* (Tuck); *Fred Funston* 1894 (CEC); *Trelease* in Harriman Exped. nos. 1268, 1270, 1298*a* (CEC); *Dall* in Harriman Exped. no. 1295, as *S. tomentosum* (CEC).

MAINE: Eastport, *Farlow* (H); Portage *L. W. Riddle* Aug. 1907 (R).

NEW HAMPSHIRE: Mt. Washington, *Farlow* Sept. 1894 (H).

MINNESOTA: *B. Fink* no. 93 (F).

OREGON: Mt. Hood, *E. Hall* 1871 (Tuck).

WASHINGTON: Mt. Rainier, *C. V. Piper* 1895 (CEC); Friday Harbor, *B. Fink* June 28, 1906 (F).

This is clearly distinct as a species from *S. tomentosum*, as the type of squamules is a specific criterion throughout the genus. It is most liable to confusion with *S. denudatum* which it resembles in general habit and range, but it can be distinguished by the tomentum and the type of cephalodium.

7. STREOCAULON DENUDATUM Floerke.

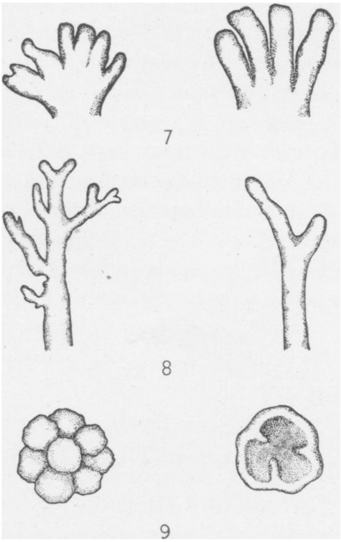
S. denudatum Flke. Deutsch. Lich. **4**:13. 1819.

S. glaubescens Tuck. Bost. Journ. Nat. Hist. **3**:302. 1840 (according to original specimen).

Podetia 2 to 4 cm. high, solitary or aggregated, shrubby-erect, subsimple below, branching above, wholly glabrous, denuded below, squamulose above; squamules crowded, in the typical form umbilicate, attached by the center, and with the margin crenate (see fig. 9), or often in the form of coarse, rounded, conglomerate granules; apothecia rare in North American specimens; cephalodia of the type of *S. paschale* (*q.v.*).—Growing on exposed rocks or soil (fig. 8).

SPECIMENS EXAMINED

Europe: Authentic specimen ex Herb. Floerke in Herb. Tuck.; Fries Lich. Suec. no. 346; Arnold Lich. Exs. no. 1576; Sweden, *Forssell* 1880 (NY); Scotland, *Leighton* July 1869 (NY); France, *L. Breviere* (R).



Figs. 7, 8, 9.—Fig. 7, palmate-digitate type of squamules found in *S. paschale* and *S. tomentosum;* enlarged; fig. 8, typical squamules of *S. coralloides;* enlarged; fig. 9, squamules of *S. denudatum;* right, umbilicate type; left, granular type; enlarged and semi-diagrammatic.

British America: Greenland, *Eberlin* 1885 (Can); *Warming* and *Holm* 1884 (H); Kikkeston Is., *Howgate Exped.* 1877 (Tuck); Hudson's Strait, *R. Bell* 1884 (Can); Labrador, *Wm. Palmer* 1887 (NY); *Owen Bryant* Aug. 22, 1908 (H); Newfoundland, no collector given (BSNH); *Delise* (Tuck) not typical.

New Hampshire: White Mts., Tuckerman Lich. Exs. no. 114; Mt. Washington, *W. G. Farlow* Sept. 1891 (H); Mt. Adams, *W. G. Farlow* Sept. 1897 (H); Mt. Willard, *E. Faxon* June 1882 (CEC); Mt. Monadnock, *W. G. Farlow* July 1896 (H).

Vermont: *C. C. Frost* (BSNH); Mt. Mansfield, *W. G. Farlow* Sept. 1890 (H).

New York: *Mrs. C. W. Harris* June 1900 (R); Adirondack Mts., *W. G. Farlow* Sept. 1902 (H).

Massachusetts: Mt. Holyoke, *Whitman* May 20, 1839 (Tuck).

Minnesota: *B. Fink* no. 49 in Herb.

Washington: *Suksdorf* (BSNH).

California: *Bolander* in Herb. Tuck. (doubtful!).

Alaska: *Dr. Kellogg* 1867 (Tuck); *W. A. Setchell*, Univ. Calif. Exped. 1899 (CEC); *W. H. Evans* 1897, as *S. alpinum* (CEC); *Harriman Exped.* no. 1279, as *S. alpinum* (CEC).

The two types of squamules described for this species intergrade, and the granulate type is scarcely worthy of varietal rank. The typical umbilicate squamules are found in specimens from arctic or subarctic stations. When these are present there should be no difficulty in distinguishing *S. denudatum* from all other species. But specimens with the coarsely granular squamules are less distinctive, and are frequently mistaken for either *S. paschale* or *S. alpinum.* From the latter the wholly glabrous podetia and the type of cephalodia should serve to distinguish *S. denudatum;* while the error of mistaking it for *S. paschale* may be avoided if it is borne in mind that in true *S. paschale* some indication of the characteristic palmate-digitate type of squamules is always to be seen, and this type is never to be found in *S. denudatum.*

The most puzzling specimens that I have seen are those collected in New Jersey by C. F. AUSTIN. Portions of this material have been examined in the Tuckerman Herbarium, the Sprague Collection at the Boston Society of Natural History, and the Herbarium of the New York Botanical Gardens. It was determined by TUCKERMAN as *S. denudatum,* and is cited in his *Synopsis of North American Lichens,* p. 233; yet it is scarcely typical of this species, and it seems much nearer to *S. paschale,* a view which would be supported by the latitude of the station, *S. denudatum* being essentially an arctic-alpine species.

According to the description of this species given by TH. FRIES, the apothecia are minute (i.e. about 0.5 mm. in diameter) and lateral. But the specimen collected by C. C. FROST in Vermont and now in the Sprague Collection (BSNH), agreeing in all other particulars with *S. denudatum,* has terminal apothecia, over 1.5 mm. in diameter.

8. STEREOCAULON WRIGHTII Tuck.

S. Wrightii Tuck. Suppl. II to Enum. N. Am. Lich. in Am. Journ. Sci. **28**: 202. 1859.

Stereocladium Wrightii Nyl. Lich. Freti Behr. p. 85. 1888.

Stereocaulon foliiforme Hue Bull. Soc. Bot. France **54**: 414. 1907 (see below).

Podetia 1 to 4 cm. tall, solitary or caespitose, branched above, wholly glabrous, denuded below, ending in broad, foliose, convolute tips, taking the place of the usual squamules; or the podetia reduced and the expanded portions alone present; apothecia unknown; cephalodia doubtful (fig. 3).

Hitherto this species has been known only from the type collection made by CHARLES WRIGHT at Arakamtchetchene Is. on the Asiatic side of Behring Strait, during the U.S. North Pacific Exploring Expedition (1853–1856). To this may now be added two other localities, from both of which specimens have been distributed under other names. A comparison of these specimens, however, with the type specimens of *S. Wrightii* in the Tuckerman Herbarium shows that they are undoubtedly this species. These specimens are from St. Michael, Alaska, collected by W. A. SETCHELL on the University of California Expedition in 1899, and distributed as *Stereocaulon denudatum;* and from Shiribeshi, Japan, collected by ABBE FAURIE, July 1905, and issued in Faurie Lich. Jap. no. 6999 as *Stereocaulon foliiforme* Hue, n. sp.; an authentic specimen determined by HUE himself is in the herbarium of W. G. FARLOW.

Section CHONDROCAULON (*Leprocaulon* Nyl.)

Primary thallus present or disappearing; podetia reduced, simple or branched; squamules granular, dissolving into chalky-white powder.

9. STEREOCAULON ALBICANS Th. Fr.

S. albicans Th. Fr. Comm. Ster. p. 36. 1857.

S. tenellum Tuck. Bot. Wilkes Voy. p. 123. 1861 (according to type specimens).

Podetia short, mostly under 1 cm., slender, caespitose, branched, crowded and intertangled; squamules minutely granular, becoming powdery; apothecia unknown.—The whole plant is characteristically chalky-white and powdery.

SPECIMENS EXAMINED

NORTH AMERICA: Greenland, Kikkeston Is., *Howgate Exped.* 1877 (Tuck); Vancouver Is., *Macoun* May 19, 1893 (Can); Colorado, *T. S. Brandegee* (BSNH); Arizona, Rincon Mts. near Tucson, *J. C. Blumer* Oct. 1909 (R); California, *C. R. Orcutt* (BSNH); *W. G. Farlow* (H); Guadeloupe Is., *E. Palmer* 1875 (Tuck); Cuba, *C. Wright* (Tuck).

SOUTH AMERICA: New Granada, *Lindig* no. 2502 (Tuck); Peru, *Wilkes Exped.* (Tuck), type of *S. tenellum* Tuck.

This is a rare and interesting species, first described by TH. FRIES from material collected by GAUDICHAUD in Peru, but with a wide distribution as indicated. It is the representative in the western hemisphere of the Old World *S. nanum* Ach. It does not resemble any other American species sufficiently to cause confusion.

DOUBTFUL SPECIES

Stereocaulon nanodes Tuck. in Suppl. II to Enum. N. A. Lichens, Am. Jour. Sci. **28**:201. 1850.

Primary thallus absent; podetia about 1 cm. tall, dendroid-branched, glabrous, more or less denuded; squamules in the form of small rounded granules, dissolving into fine, whitish powder (but not chalky as in *S. nanum*); apothecia terminal, or absent and the podetia ending in masses of soredia as *S. pileatum*.—Spores 24–42 × 2.5–3 μ.

I have examined at the Tuckerman Herbarium the type specimens of this species, collected by TUCKERMAN at Crystal Falls, Saco Falls, and upper gorge of the Ammonoosuck, in the White Mts., New Hampshire. Although not readily referable to any other species of *Stereocaulon*, I have placed this species as doubtful on account of the fact that it has apparently never been collected again in the White Mts., which is perhaps one of the most thoroughly explored regions, botanically, in North America. The only other record of this species is Newfoundland on the authority of Dr. J. W. ECKFELDT. Through the courtesy of Mr. WITMER STONE of the Philadelphia Academy of Sciences I have had an opportunity to examine the specimens upon which this record was based. One sheet is *S. pileatum* Ach.; the other, depauperate specimens of *Cladonia decorticata* (Flke.) Spreng. The species is known, therefore, only from the type collections.

Stereocaulon ramulosum (Sw.) Ach.

In the herbarium of the Geological Survey of Canada is a sheet bearing three specimens of this species with the label: "Lichenes Boreali Americani. No. 89. Dalles, Oregon, on the earth. Legi John W. Eckfeldt. 1880." As no corresponding specimens are to be found in Dr. ECKFELDT'S herbarium at the Philadelphia Academy of Sciences, and as *S. ramulosum* is not otherwise known from the United States, there has undoubtedly been some mistake in the labeling of the specimens mentioned above.

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